matfyz

Computer Graphics Charles University

Computer Graphics I
NPGR 003

CGG MFF UK Praha

pepca@cgg.mff.cuni.cz

http://cgg.mff.cuni.cz/~pepca/

Vector graphics

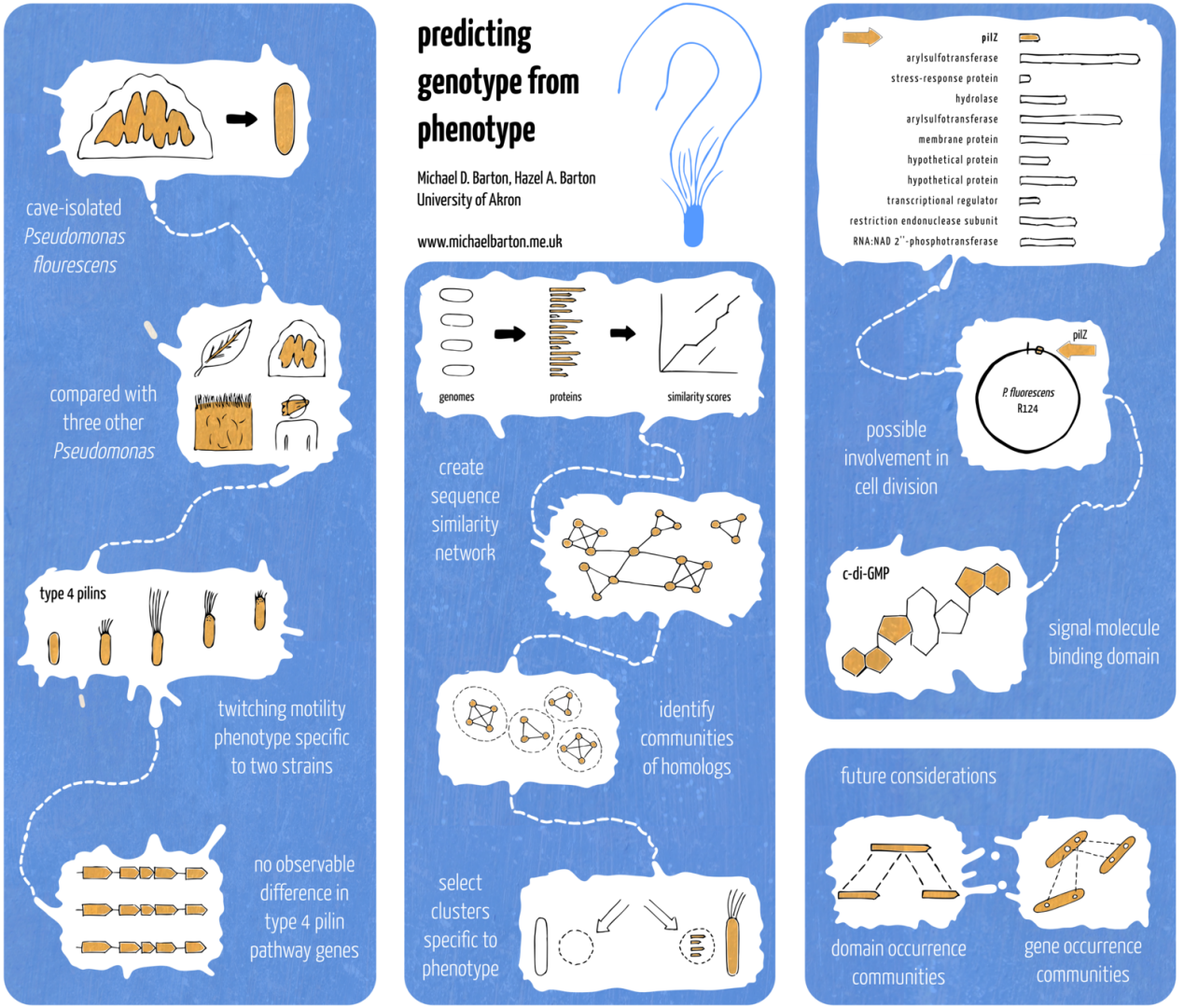
© 2014, Saylerman

Vector graphics

- **interactive editing**
  – splines†, free-form drawing
- **colors***
- **vector image format***
  – SVG, PDF, EPS, DXF, AI
- **transparency***
- **vectorization tool**

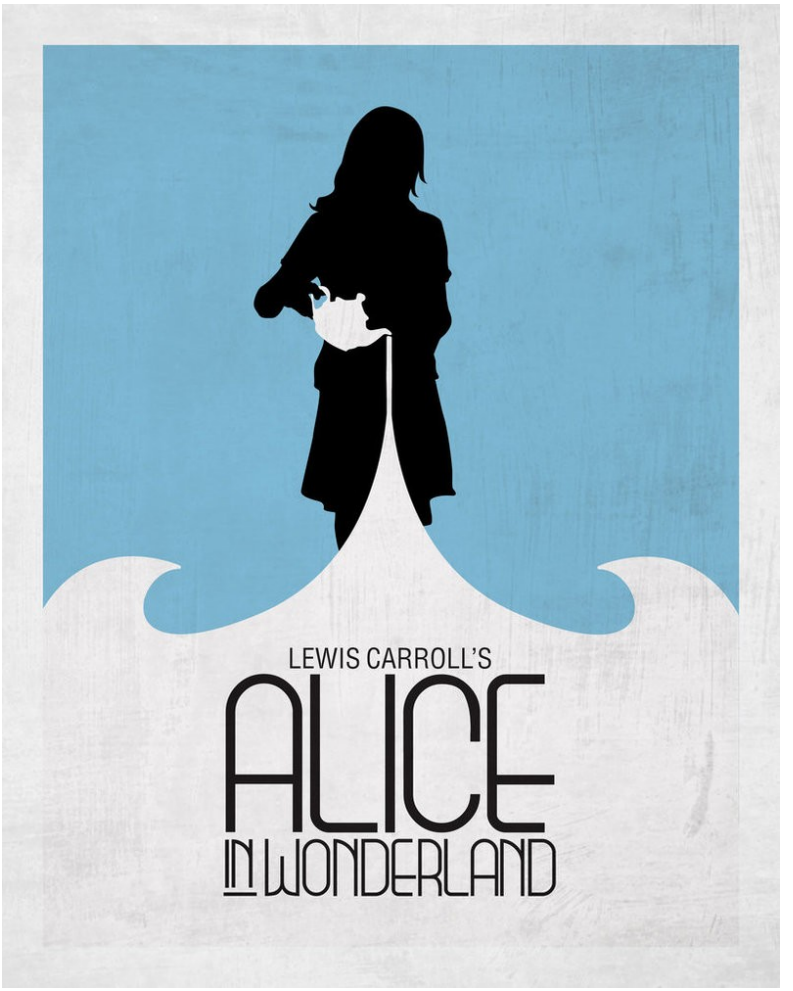
*** … in this course**
† … in other courses

Poster, billboard



Poster, billboard

© 1939, Charles Vershuuren



© DaveForYou

Digitized poster

- **digital photography**
- **color balance†**
- **raster image***
  – PNG, TIFF, JPEG
- **image rotation†**

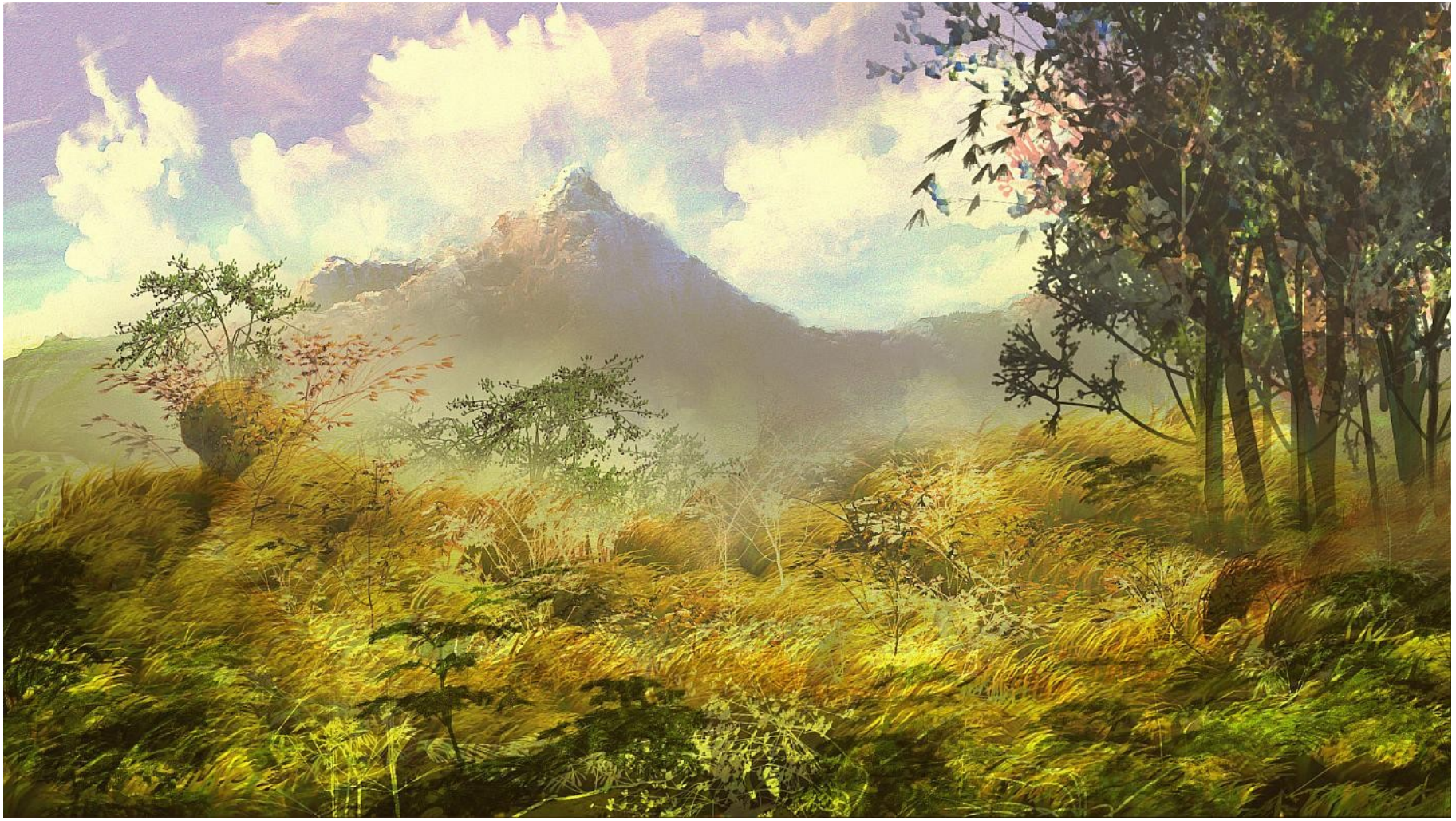
Poster print:

- **color conversion***
  – RGB to CMYK
- **digital halftoning***

Digital painting, 2D effects

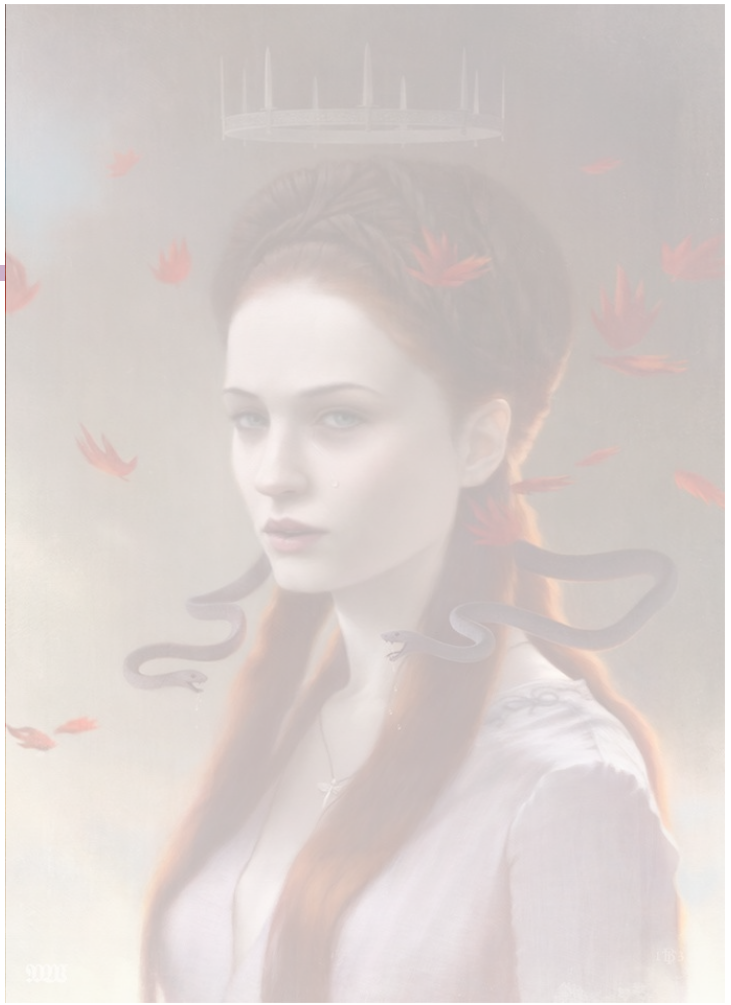
© Corel Painter, Hahin

Digital painting tools



© Dan Ritchie (PD Particles)

Digital painting



- **interactive editing**
  - pens, brushes, special tools
  - „undo“
  - touchpad, touchpen, digitizer
- **colors***
- **transparency***
- **painterly effects***

Digital photography

© 2016, DP Review

Digital photography

- **autofocus**
  – edge-detection†
- **colors***
  – white balance
- **raster image format***
  – JPEG, RAW
- **denoise†**
- **HDR***
  – super-bracketing

Digital effects – Photoshop, GiMP

© 2015, IT Roshni

Digital effects

- **interactive editing**
  - pens, brushes, tools
  - „undo“
- **colors***
- **raster image format***
  - JPEG, PNG, TIFF
- **special effect filters*†**
  - image enhancing, edge operators, histogram operation, ..
  - color transforms (rebalance..)

HDR photography

© 2015, Andrea Baldwin

HDR photography

© 2013, Jimmy McIntyre

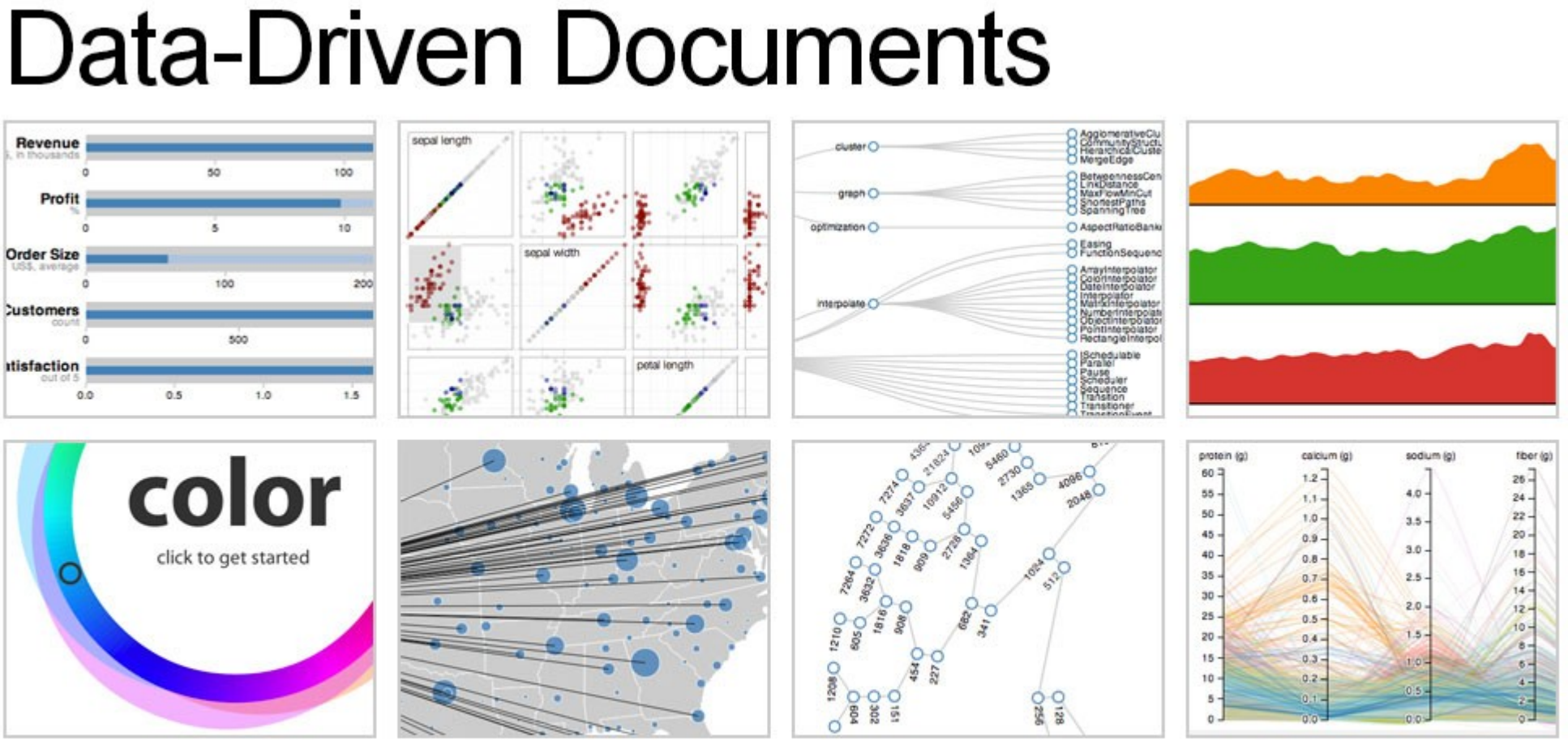
HDR photography

© Conor MacNeill (TheFella)

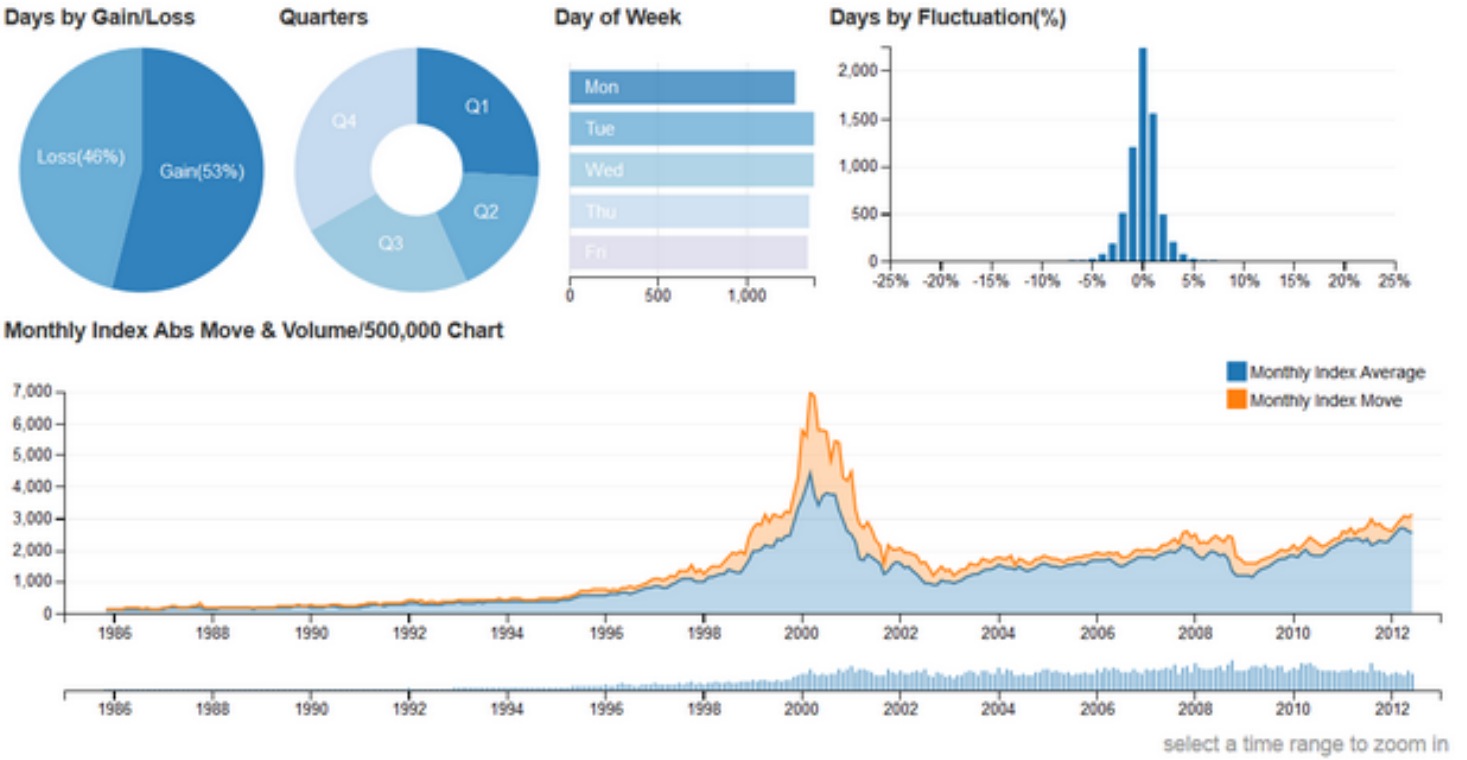
HDR photography

- **HDR acquisition***
  - multiple exposure
  - „super-bracketing“
- **colors***
- **HDR image format***
  - HDR, EXR, PFM
- **tone-mapping***

Web design, data visualisation



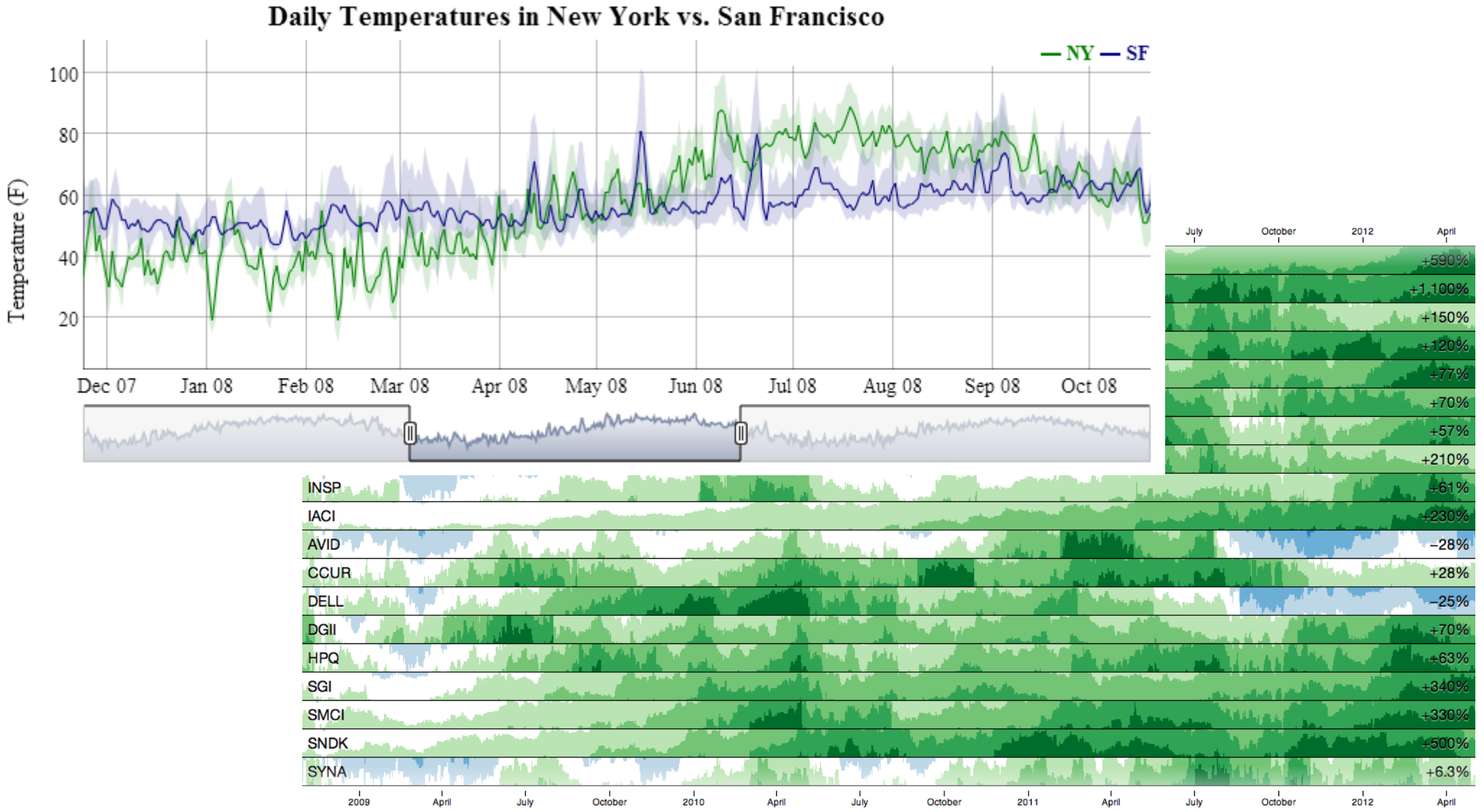
Web design, data visualisation



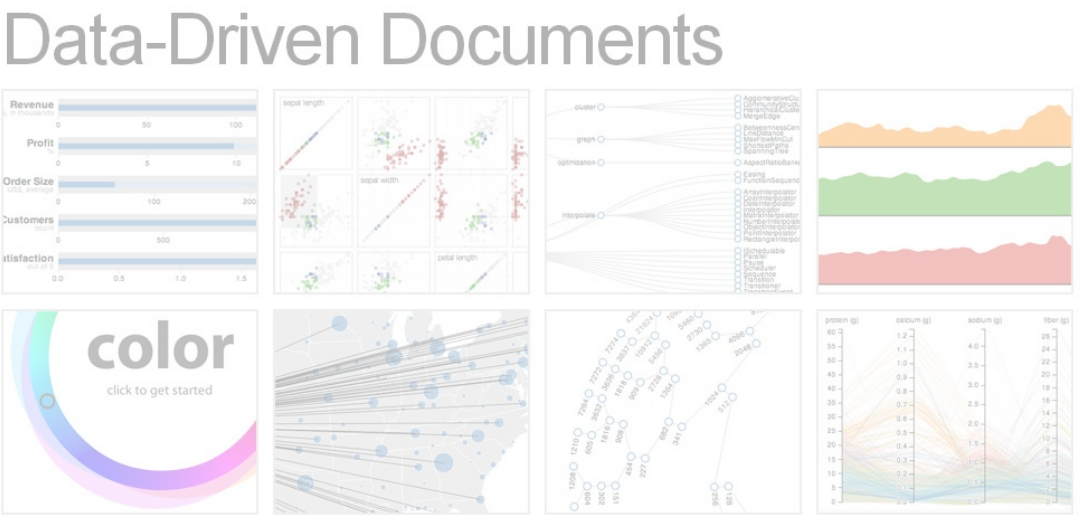
6,724 selected out of 6,724 records | Reset All

Date	Open	Close	Change	Volume
2012/06				
06/18/2012	2570.98	2592.52	21.54	15407330
06/19/2012	2606.43	2620.83	14.40	17714840

Interactive data on web

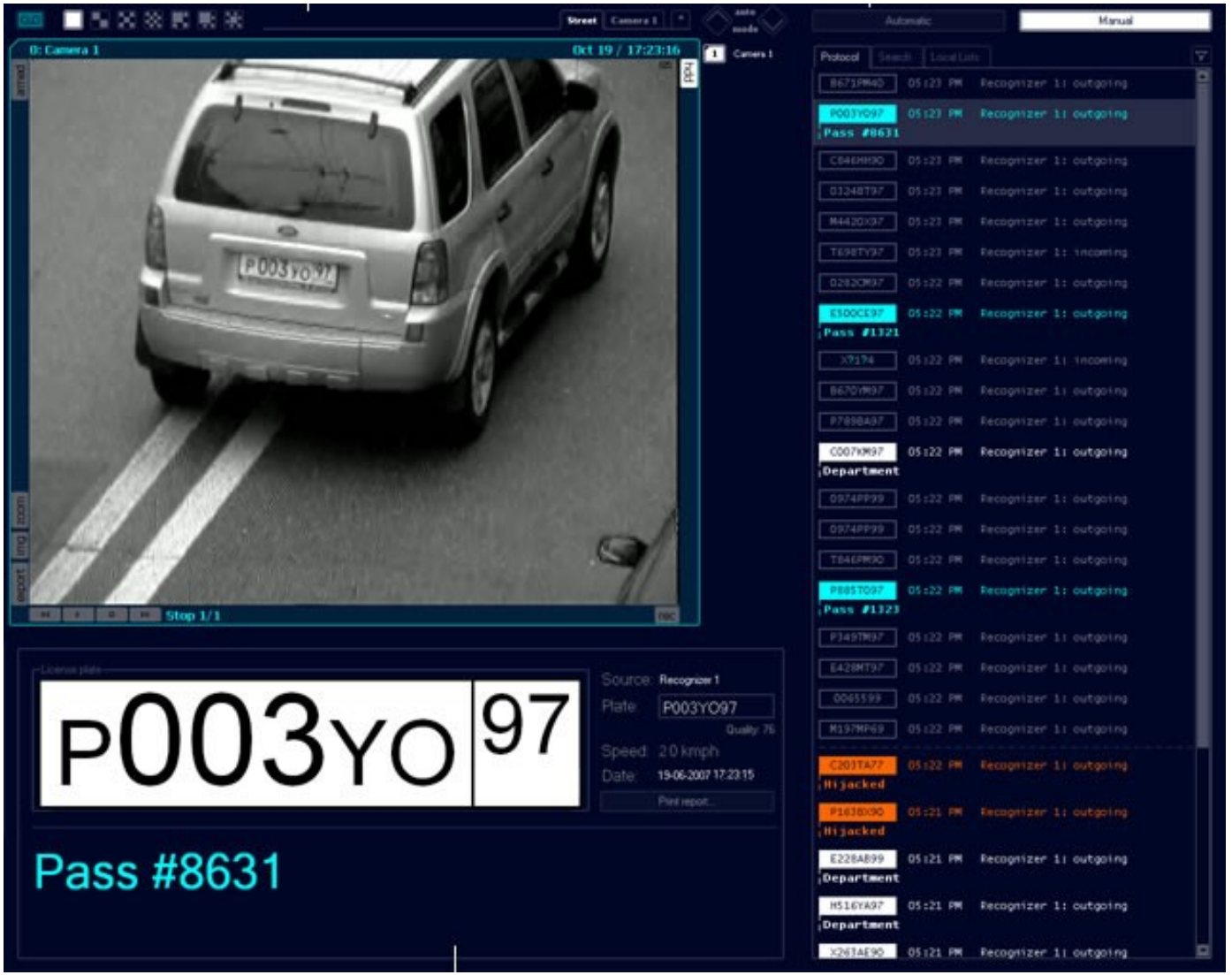


Modern web



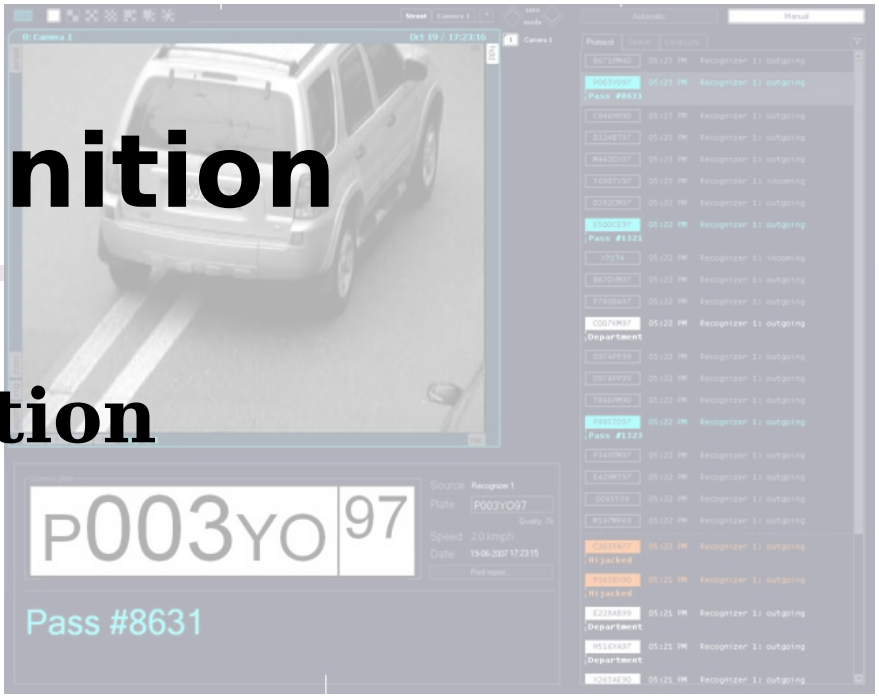
- **HTML5†, CSS3†**
  - JavaScript
  - templates, WordPress
- **interactivity†**
- **Data-Driven Documents†**
  - d3.js library
- **WebGL for 3D†**
  - interactivity
- **video, 360-degree video**

License-plate recognition



© Smart Security Camera, Inc.

License-plate recognition



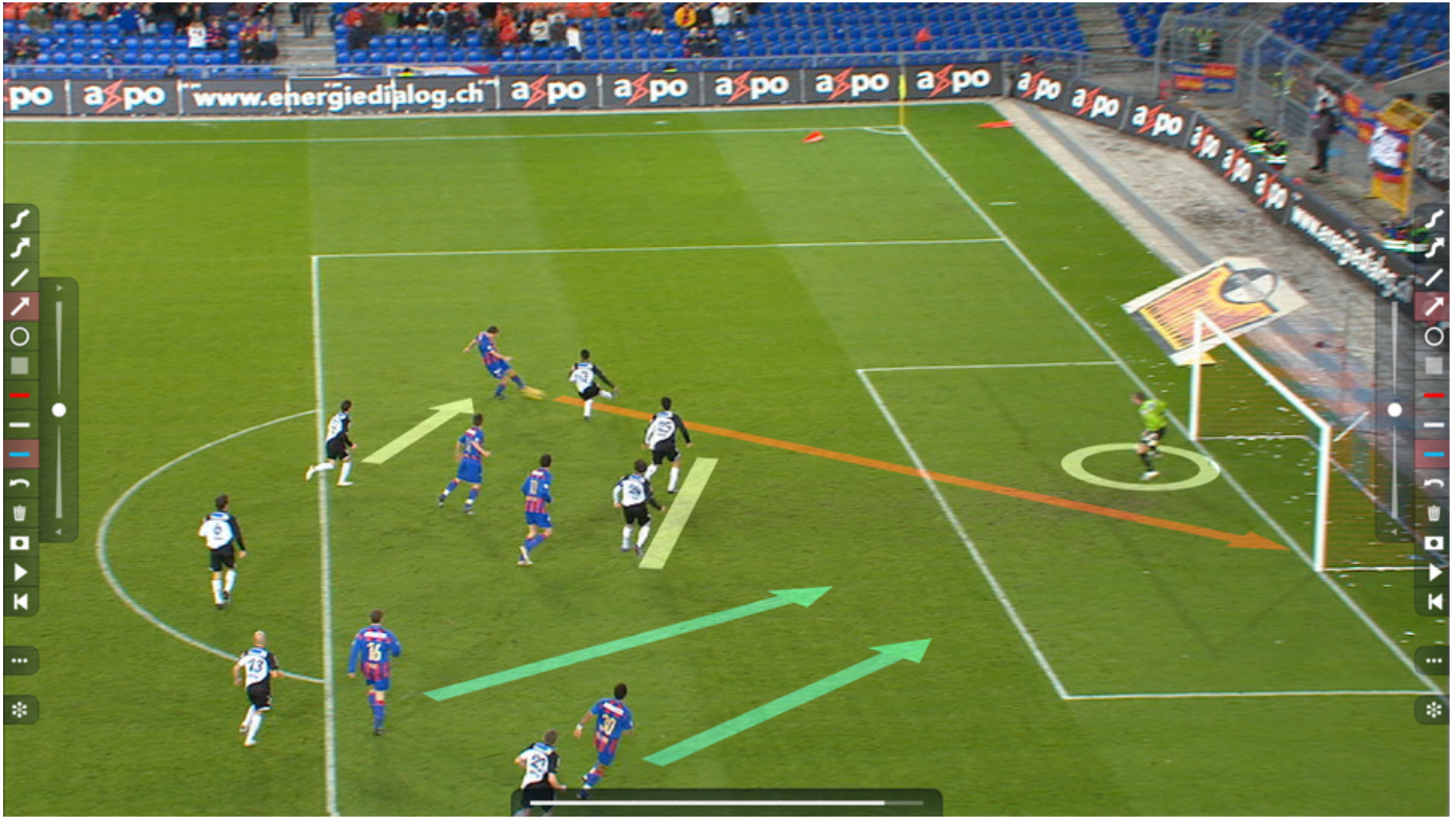
- **real-time image acquisition**
- **plate segmentation†**
- **image warping†**
- **glyph recognition†**
- speed measurement.. ?

Sport live on TV

Sport live on TV

- **vector graphics***
  – real-time!
- **transparency***
- **real-time video signal composition**
  – real-time video compression†

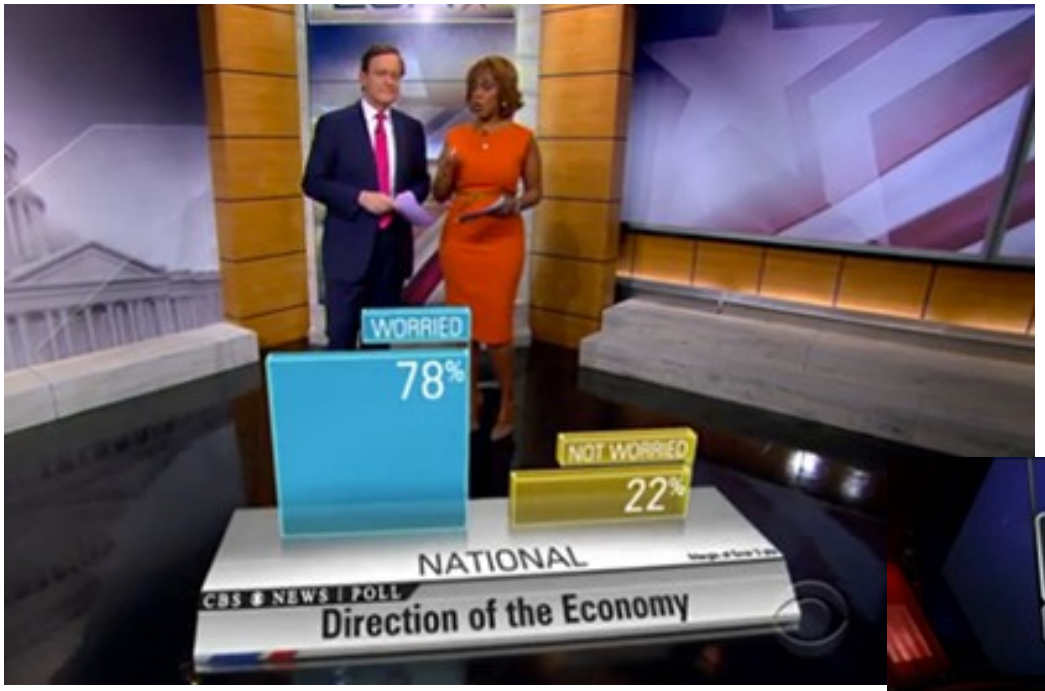
„Next-generation“ sport TV

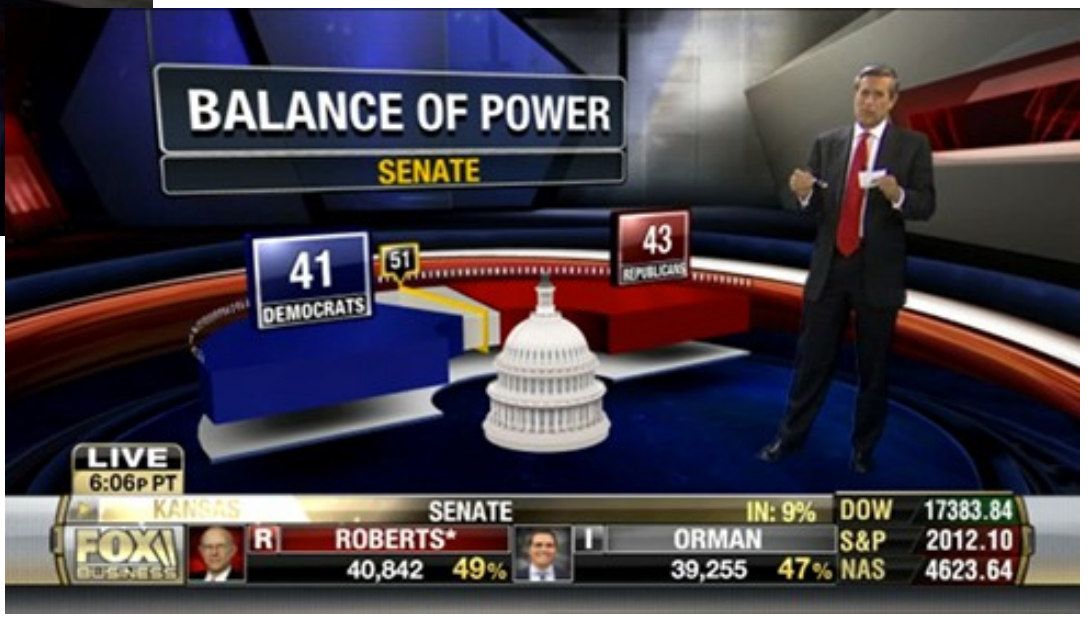


„Next-generation“ sport TV

- **3D computer vision†**
  - camera calibration
  - object recognition, segmentation
- **3D „extra“ model***
- **real-time interaction ?**
  - reporter in a studio..
- **real-time video composition**
  - layers, transparency*
  - video compression†

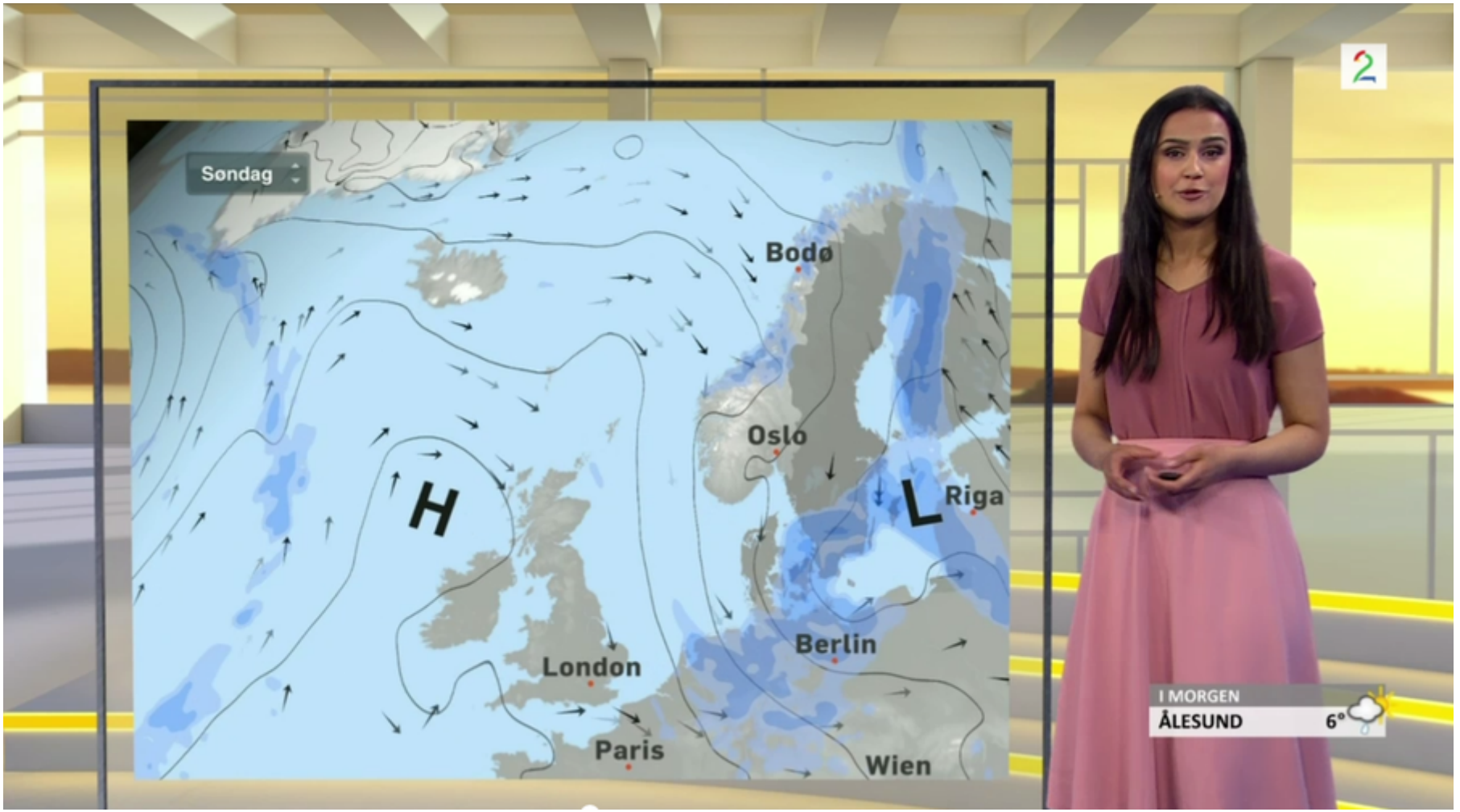
Virtual TV studio





© CBS, FOX TV

Virtual TV studio

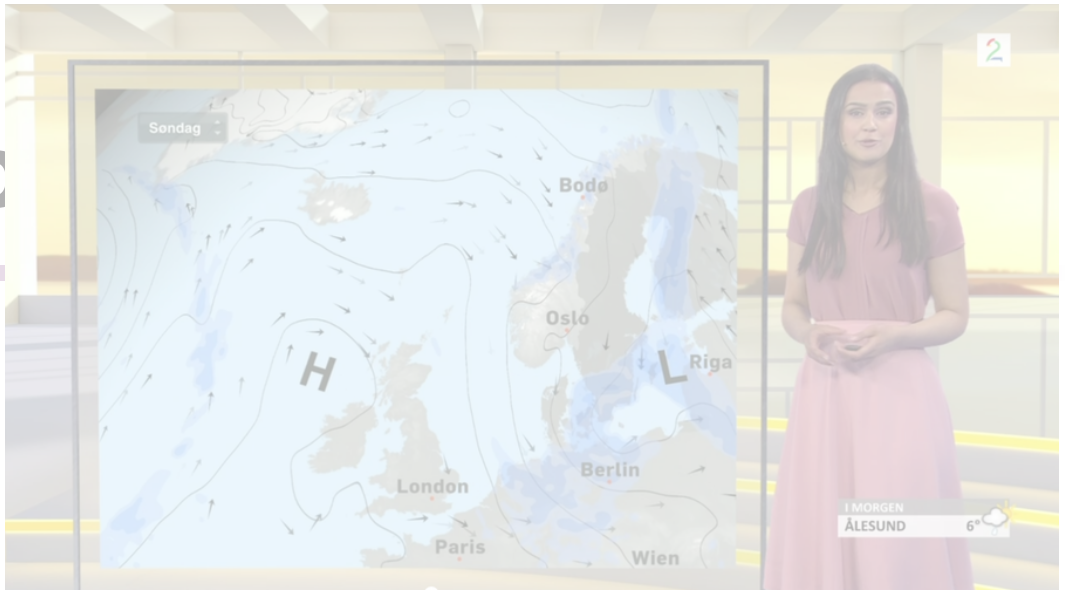


© TV 2

Green screen („virtual studio“)

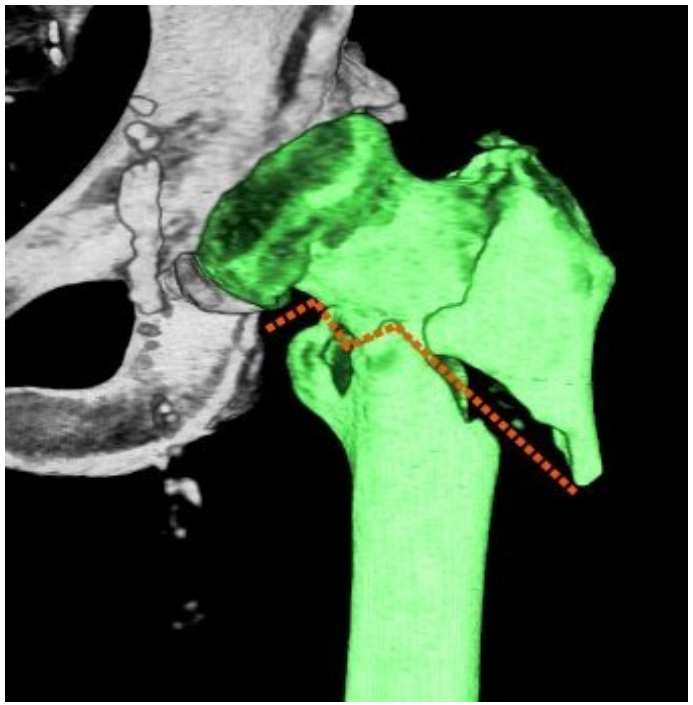
© 2009, vr3 virtual production oHG

Virtual TV studio



- **„green-screen“**
  – keying in hardware
- **3D virtual model***
  – can be dynamic (animations, additional video channels..)
- **real-time video composition**
  – layers, transparency*
- **video compression†**
  – all in real-time

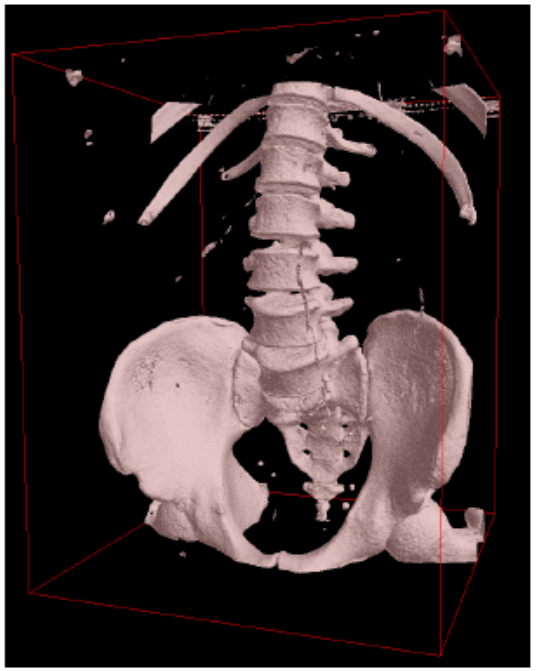
Medical data



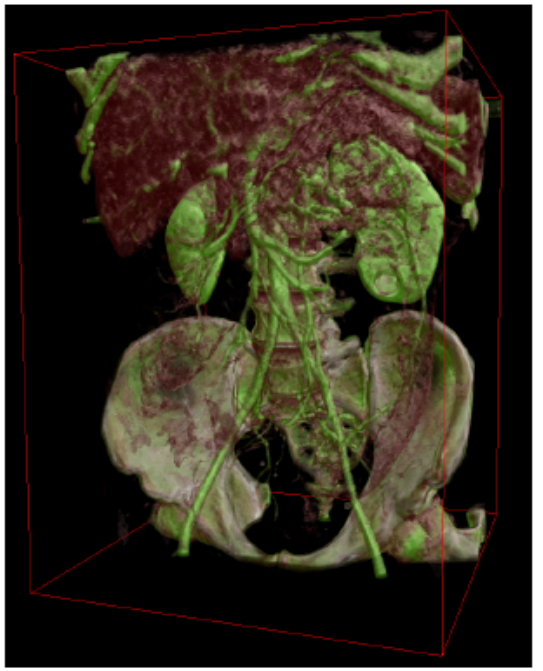
© 2016, Jan Horáček,
Jan Kolomazník

(a) Maximum intensity projection

(b) Density integration

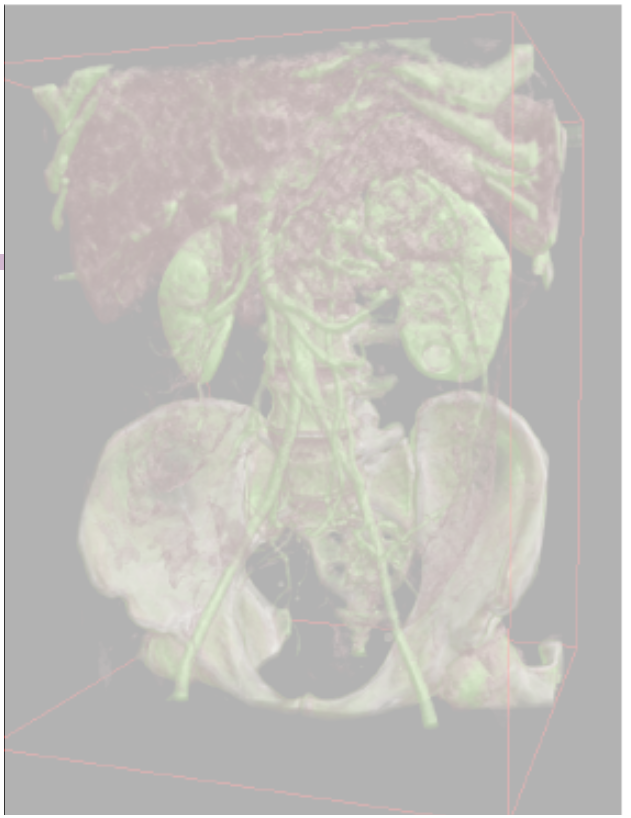


(c) Isosurfaces



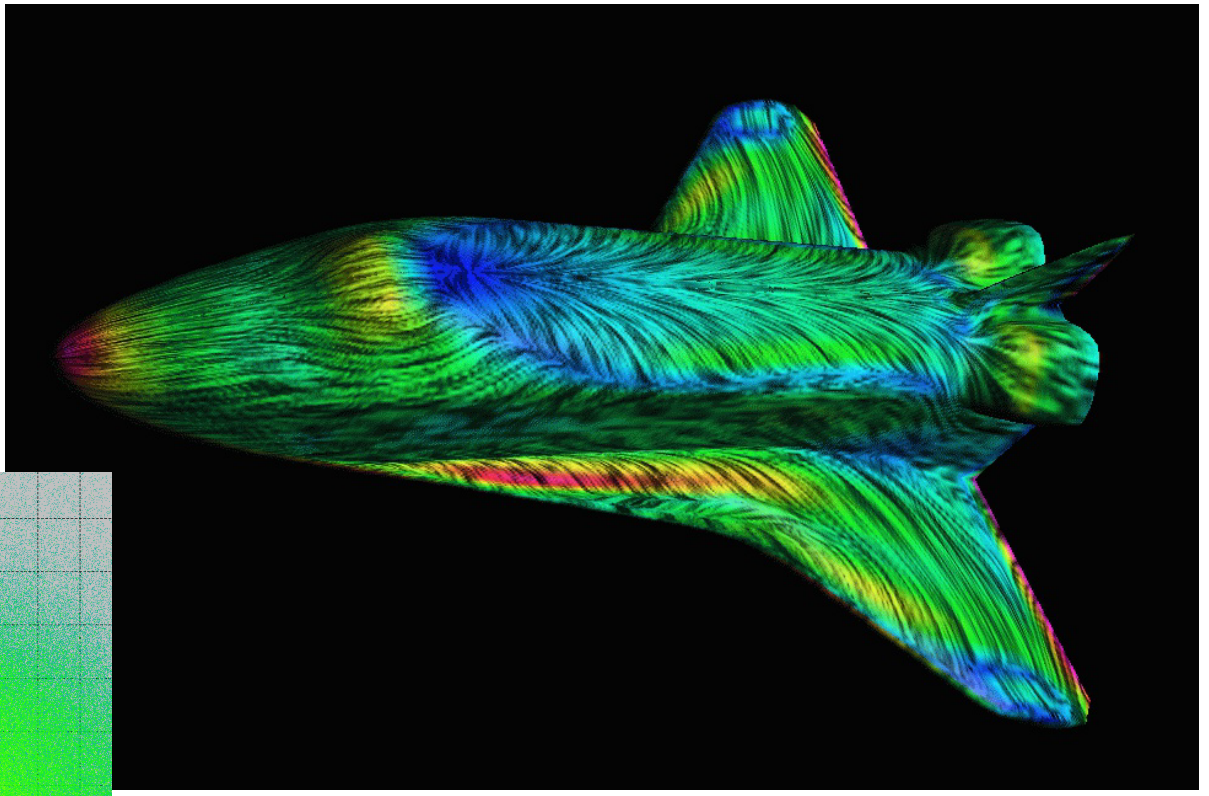
(d) 1D transfer function

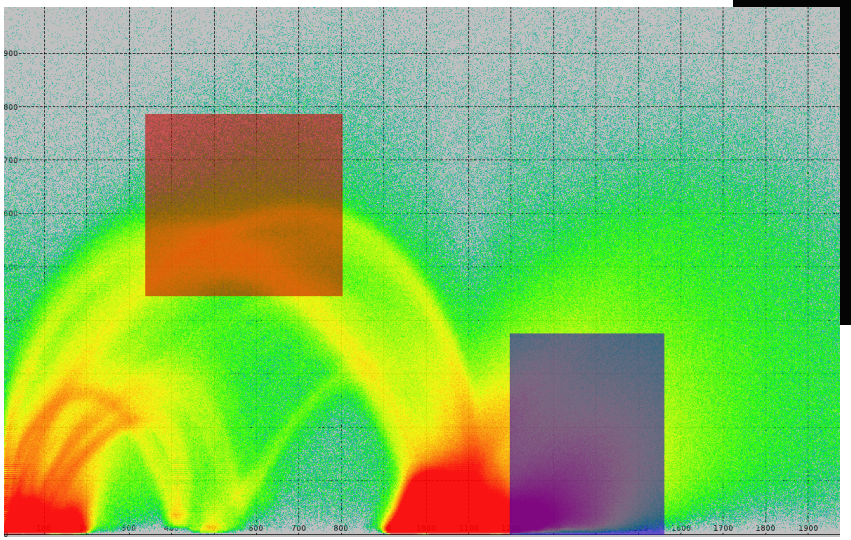
Medical data



- **volume data acquisition†**
  - Computer Tomography
  - Magnetic Resonance Imaging, ..
- **data enhancement†**
  - de-noise, contrast (CUDA†, GPU†)
- **segmentation†**
  - organs, vessels, bowels (CUDA†, GPU†)
- **real-time volume rendering†**
  - ray-casting on GPU
- **measurements, ..**

Scientific visualization

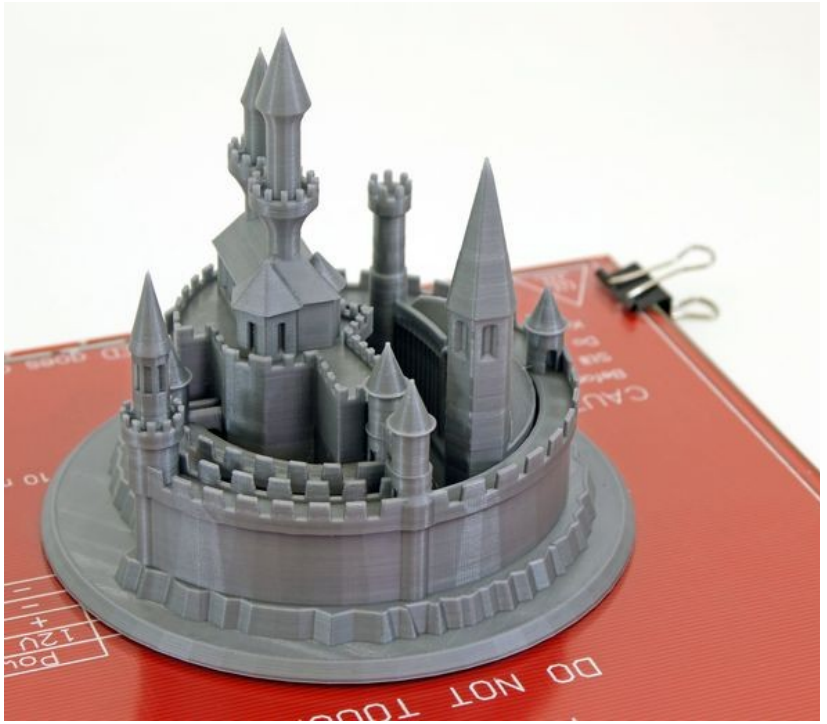




Scientific visualization

- **data acquisition†**
  - numeric simulation
  - measurements, ..
- **visualization primitives†**
  - streamlines, arrows, ..
- **real-time rendering†**
  - vanilla 3D or full volume rendering (CUDA†, GPU†)
- **interaction†**
  - „steering“
- **measurements, ..**

3D printing



3D printing

- **3D model editor†**
  – CSG, triangle-mesh, ..
- **„rendering“, rasterization**
  – similar to 2D rasterization*
- **geometric optimization**
  – stiffness simulation ?

Realistic rendering - Corona

© Bertrand Benoit, Pavel Stavila

Realistic rendering

- **3D scene model***
- **3D editing†**
  – 3DS Max, Blender, Rhinoceros
- **materials*†**
  – surface appearance, textures†
- **lighting†**
  – primary light sources + global illumination (GI) simulation†
- **HDR results***

Computer animation

© 2007, DreamWorks Animation SKG

Computer animation

© 2007, DreamWorks Animation SKG

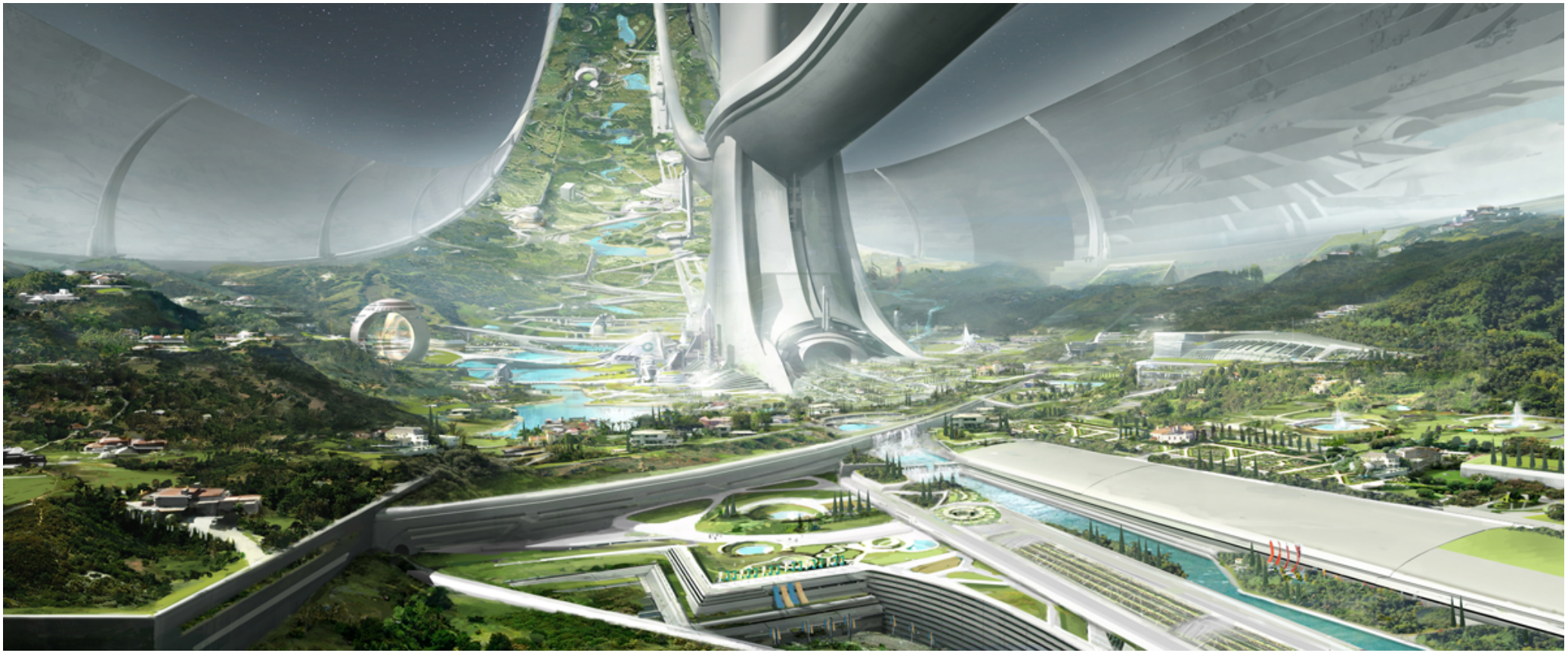
Computer animation

© 2015, Pixar Animation Studios, Walt Disney Pictures

Computer animation

- **3D scene model***
- **3D/animation editing†**
- **realistic rendering*†**
  - off-line (CUDA†, GPU†)
  - materials, textures, appearance models
  - lighting with GI
- **video-compression†**
  - off-line

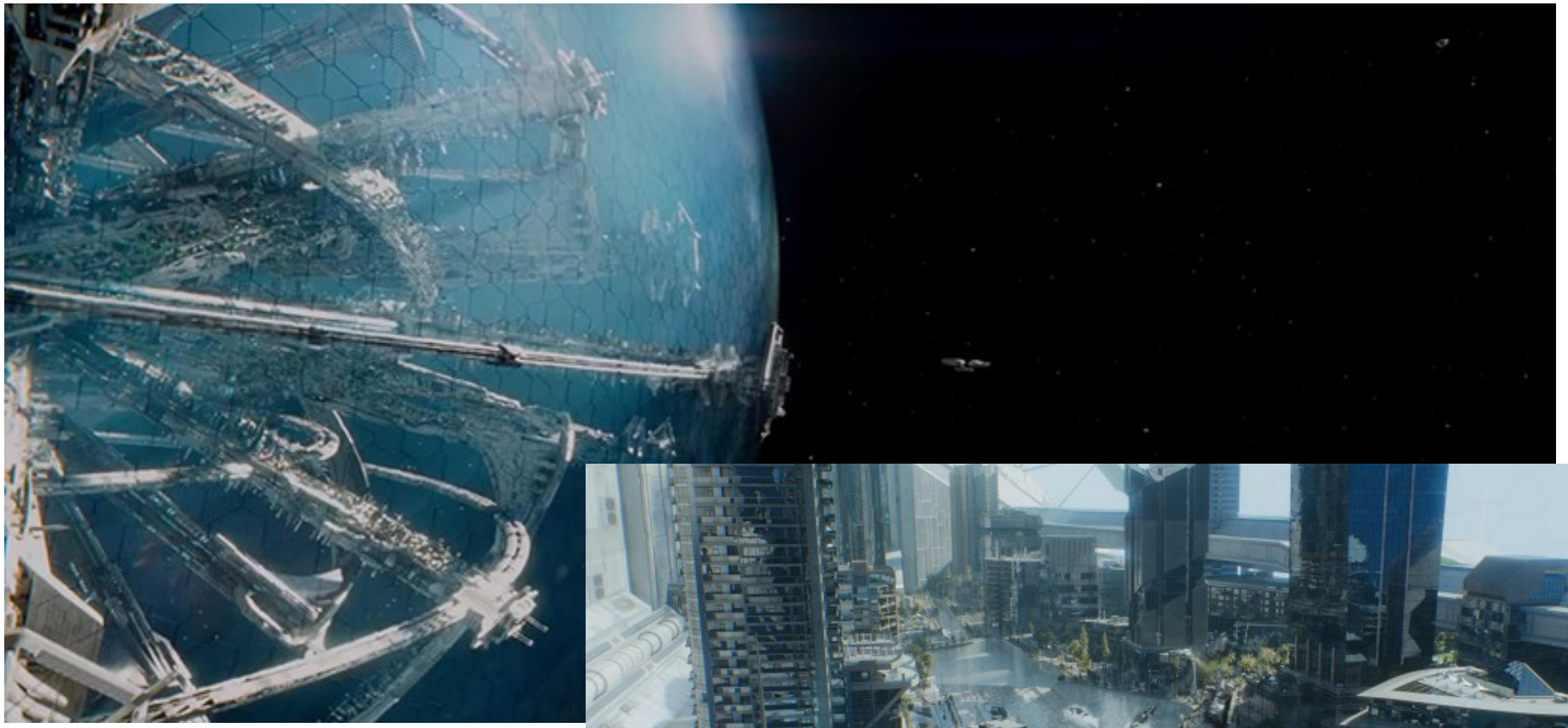
CGI in film - Elysium



© 2013, TriStar Pictures

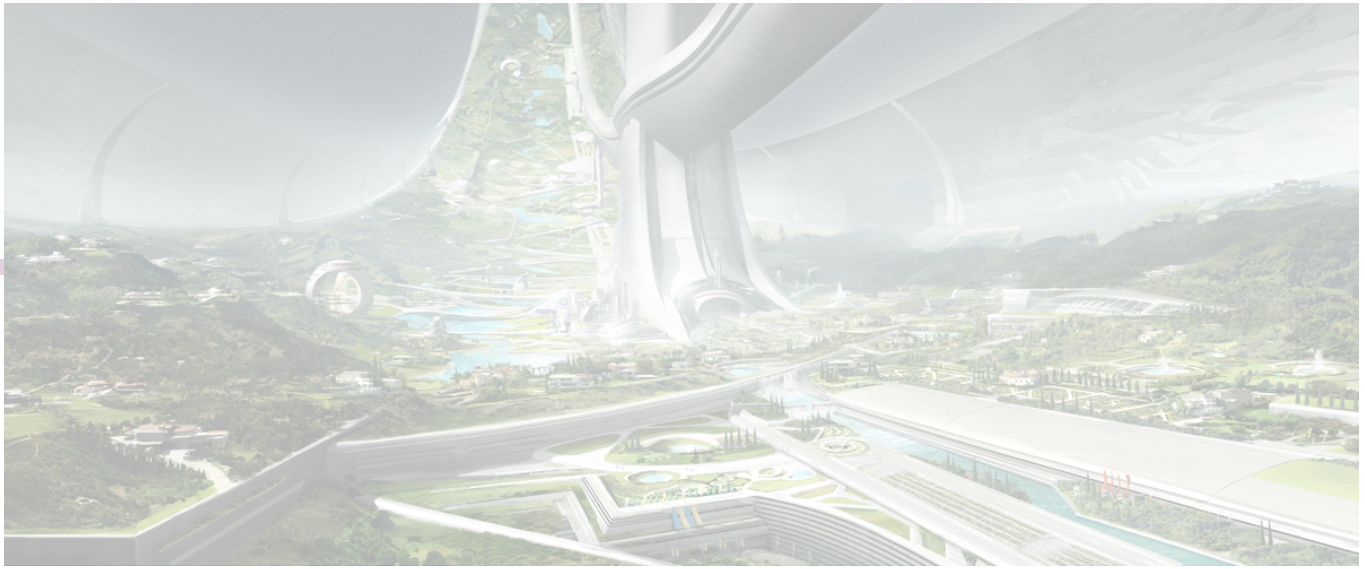
CGI in film – Star Trek into Darkness

CGI in film – Star Trek Beyond



© 2016, Double Negative, Paramount Pictures

CGI in film



- **3D scene model***
- **3D/animation editing†**
- **photo-realistic rendering*†**
  - off-line (CUDA†, GPU†)
  - materials, textures, appearance + global illumination
- **video-compression†**
  - off-line

VFX – The Perfect Storm

The Perfect Sto

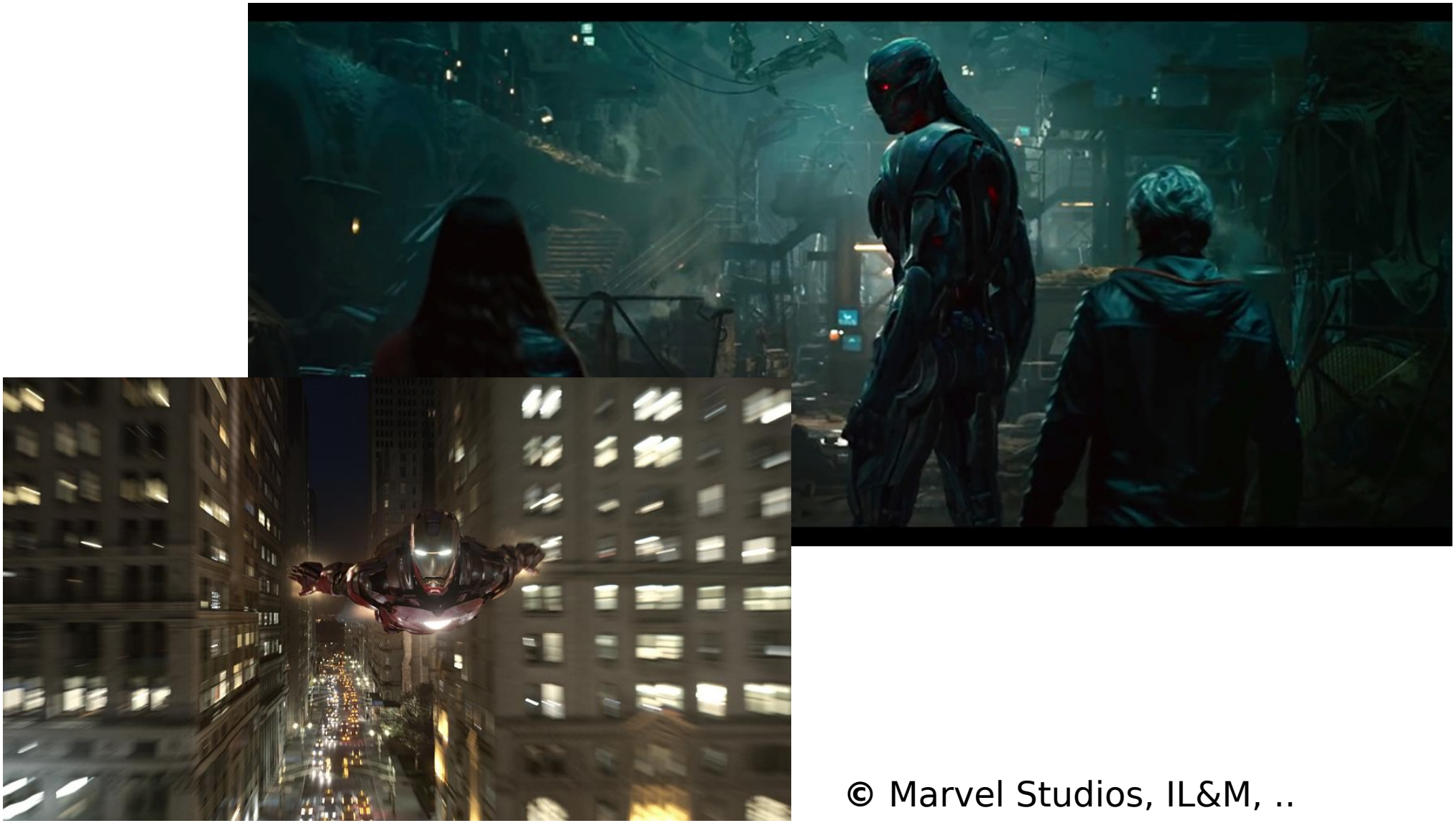
- **numeric ocean-water model!**
  – incl. realistic rendering of water
- **3D/animation editing†**
- **video composition and compression†**
  – off-line

VFX – The Perfect Storm

VFX - Marvel

© Marvel Studios, Paramount Pictures, IL&M, ..

VFX - Marvel



© Marvel Studios, IL&M, ..

VFX – Tron Legacy

© 2010, Disney Enterprises, Inc.

VFX – Tron Legacy

© 2010, Disney Enterprises, Inc.

VFX – Tron Legacy (color scheme)

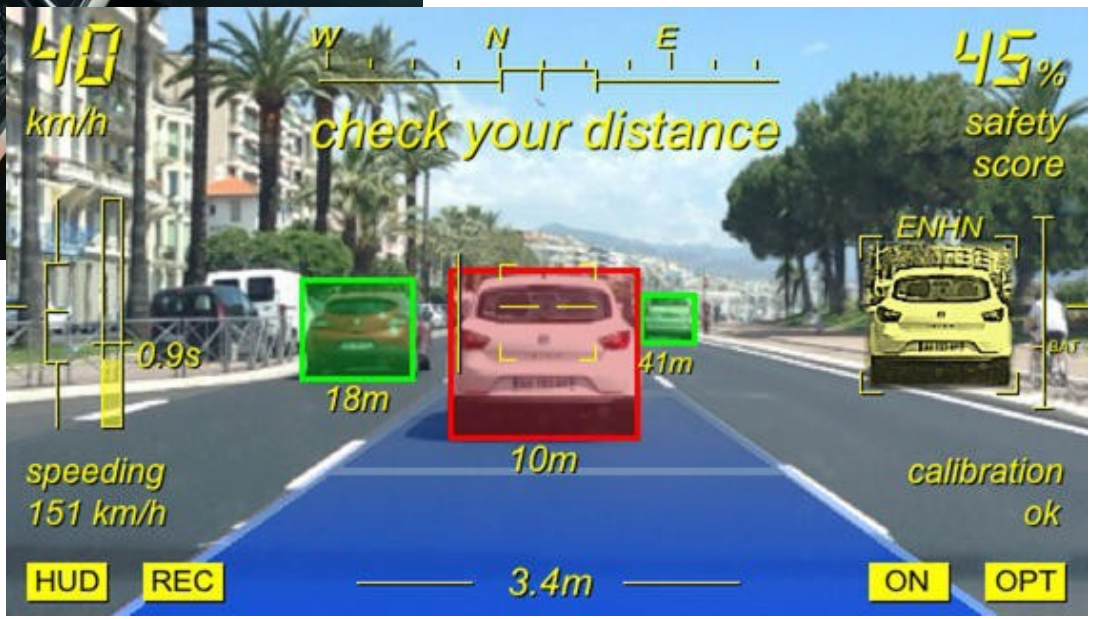
VFX – Tron Legacy

- **motion capture !**
  – incl. green-screen keying
- **3D scene model***
- **3D/animation editing†**
- **photo-realistic rendering*†**
  – off-line (CUDA†, GPU†)
  – materials, textures, appearance + global illumination
- **video-compression†**
  – off-line

Self-driving car

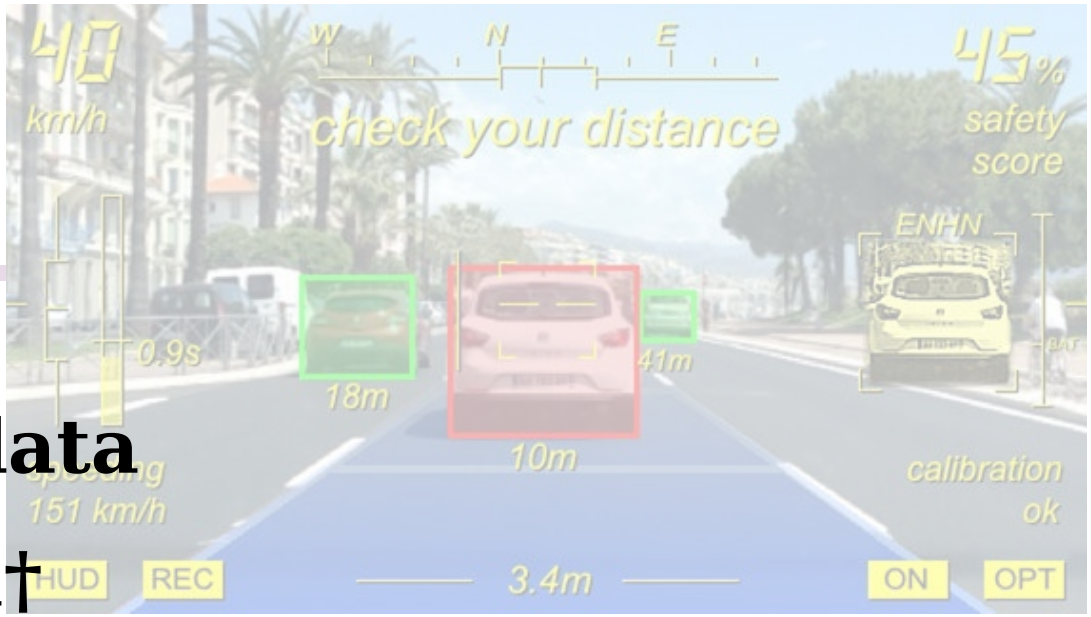
© Tesla Motors ?

Self-driving car



© Volvo

Self-driving car



- **real-time camera data**
- **camera calibration†**
  – as accurate 3D context as possible
- **3D computer vision†**
  – robust!
  – real-time! (no lags)
- **prediction, planning**
  – artificial intelligence
- **actual steering**

Videogame – DayZ (Arma II mod)

Videogame – Kingdom Come: Deliverance

© 2016-2017 Warhorse Studios

Videogame - Overwatch

© 2016, Blizzard Entertainment

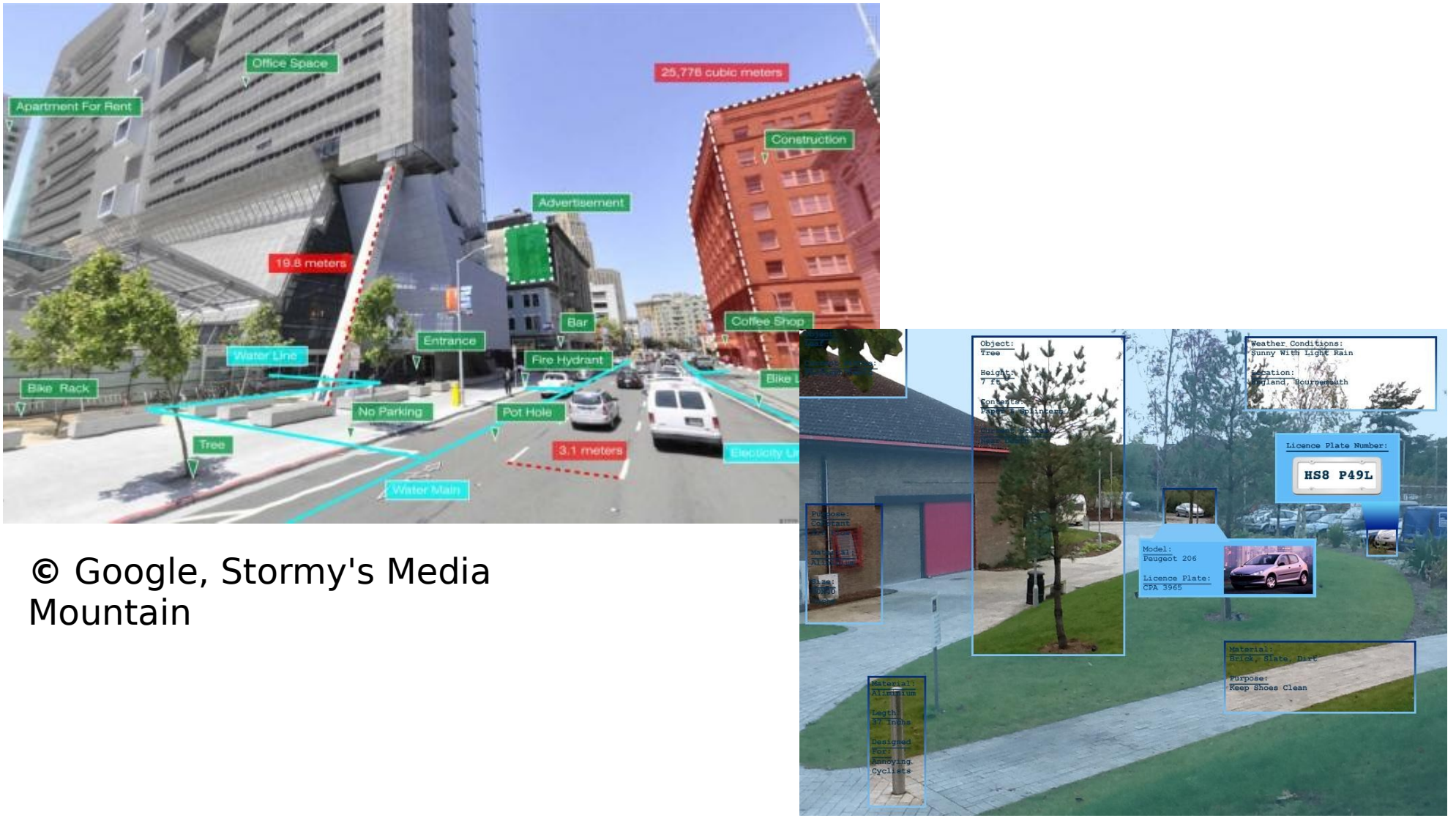
Videogames

- **3D editing, tools**
- **game logic†**
  - interaction among virtual objects
- **user interaction†**
- **real-time rendering†***
  - constant FPS, textures, LoD, GPU shaders†
  - scene virtualization (potentially infinite scene), ..
- **agents, AI players†**
- **multiplayer**
  - LAN layer, lag compensation

Virtual reality - „cave“

© 2011, Land Rover

Augmented reality – „smart glasses“



© Google, Stormy's Media Mountain

Augmented reality – „smart glasses“

© 2016, Epson (Moverio BT 300)

Augmented reality – military

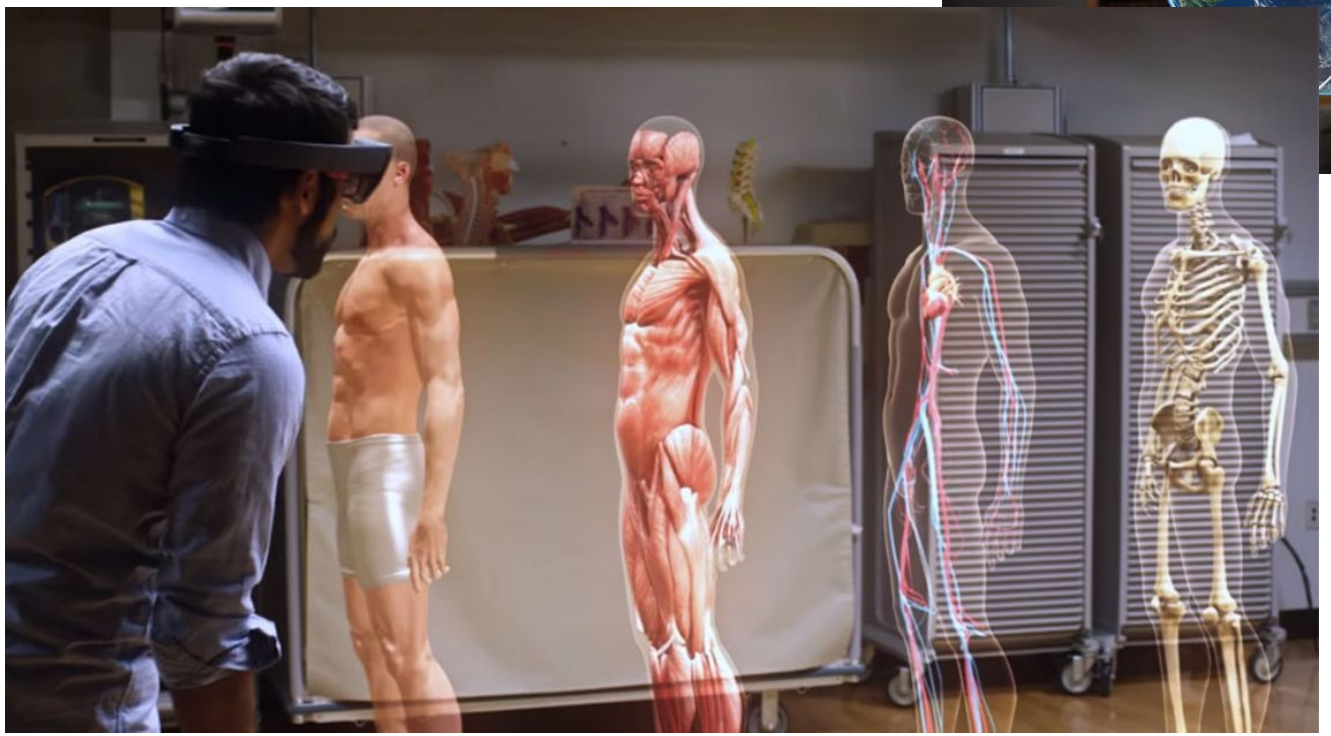
Augmented reality - phone

© 2012, JP

Augmented reality - tablet

© RE'FLEKT GmbH

Augmented reality - HoloLens



© 2016 Microsoft

Augmented reality - HoloLens

Augmented reality

- **virtual 3D scene***
- **3D position†**
  – with help of computer vision?
- **real-time rendering*†**
  – GPU, shaders†
  – no lags will be tolerated !
- **interactivity†**
  – computer vision† or different..

Computer Graphcis I

NPGR003

ZS 2/2 Z, Zk

Course Content and Form

- **The basics of 2D and 3D graphics**
  - Follow-up courses in Czech include:
  - Počitačová grafika II (NPGR004)
  - Hardware pro počítačovou grafiku (NPGR019)
  - Pokročilá 2D počítačová grafika (NPGR019)
  - Visualizace (NPGR023)
- **2 units lecture, 2 units practical exercise**
  - Regular weekly schedule
  - Exercise: C# programs
  - Overall grade based on lecture exam and exercise

Lecture Overview 2D

- **Raster and Vector Graphics**
  - Raster images, transparency, HDR, bitmap operations
- **Colour**
  - Colour Vision, colour spaces, colour reproduction
- **Raster Image Formats**
  - JFIF, GIF, JPEG, PNG, ...
- **Raster Drawing**
  - Drawing lines & curves, shape filling, curve trimming

Lecture Overview 3D

- **The mathematics of 3D graphics**
  - Linear transforms, homogenous coordinates, projections
- **3D scene representations**
  - implicit, explicit, volume models
- **Introduction to OpenGL**
  - Displaying 3D scenes, visibility
- **Visibility algorithms**
  - Ray tracing, basics of shading

Literature

- **J. Foley, A. van Dam, S. Feiner, J. Hughes**: ***Computer Graphics, Principles and Practice***, 2nd edition in C, Addison-Wesley, 1995
- **Peter Shirley**: ***Fundamentals of Computer Graphics***, 3rd edition, A K Peters, 2009

Requirements

- **Basic programming**
  - algorithms, data structures
- **Basics of programming in C#**
  - No in-depth knowledge of language or libraries is needed
  - The practical exercise consists of framework assignments
- **Basic analysis and linear algebra**

Important Web Addresses

- Lecture information on the **WWW:**
  - **http://cgg.mff.cuni.cz/prednasky.en.php**
  - **http://cgg.mff.cuni.cz/~pepca/**
- Downloads for the practical exercise:
  - **http://cgg.mff.cuni.cz/~pepca/grcis/**
  - **svn://cgg.mff.cuni.cz/grcis/trunk/**

Other Graphics Lectures (Winter Sem.)

- **Geometrie pro počítačovou grafiku**
  – 2/0, NPGR020 (Zbyněk Šír)
- **Digitální zpracování obrazu**
  – 3/0, NPGR002 (Jan Flusser, ÚTIA AV ČR)
- **Počítačové vidění a inteligentní robotika**
  – 2/0, NPGR001 (Václav Hlaváč, FEL ČVUT)
- **Introduction to Colour Science**
  – 2/0, NPGR025 (Alexander Wilkie, KSVI)
- **Virtuální realita**
  – 2/1, NPGR012 (Jiří Žára, FEL ČVUT)

Interesting Events for Participants

- **HiVisComp** Conference
  - Every year in winter (with skiing), a meeting of graphics researchers and students from CZ and SK.
  - **1. - 4. 2. 2017**
  - **http://www.hiviscomp.cz/**

- **CESCG** Student Conference
  - Presentation of student projects and research
  - AT, SK, CZ, PL, DE, and others
  - **http://www.cescg.org/**